*Final Draft 18/09/98*

Ontario

# *CONDITIONS NEAR THE COLDWATER FISHERIES*
# *EAGLE ROCK SITE*
# *DURING JUNE AND JULY 1998*

*Provisional Data Summary and Interpretation for Discussion*

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# ***Acknowledgements***

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## 1. Background

MOE is currently providing recommendations to MNR in the development of a provincial policy governing aquaculture operations in Ontario. The Manitoulin area of Lake Huron's North Channel is the site of numerous aquaculture operations, and there is considerable pressure to expand the scale of existing operations as well as to allow the siting of additional facilities.

One operation in particular, the Cold Water Fisheries Inc. LaCloche site, has been decommissioned following anoxia problems and MOE staff in the Sudbury District office requested an investigation of the local flow regime, water quality conditions and potential recovery time at this site as an addition to their ongoing monitoring at this location. Additional assistance was also requested in measuring the effects on local water quality of the operational Eagle Rock site run by this same company outside the Boat Passage offshore from Little LaCloche Island (southwest of McGregor Bay).

Unlike the Cold Water Fisheries Inc. LaCloche site, the Eagle Rock facility is situated in an unconfined area which is open McGregor Bay (see Figure 1). The company has asserted that the assimilative capacity associated with this location is sufficient to not only accommodate the existing scale of operations, but can support an expanded operation.

The 1998 field work undertaken by EMRB in collaboration with Northern Region during June and July in the vicinity of the Eagle Rock site included:

(a) measurement of "typical" daily summer current regimes,

(b) measurement of depth profiles for dissolved oxygen (DO), temperature, and pH in the vicinity of the fish cages and at a reference site, and

(c) collection of near-surface, mid-depth, and near-bed grab samples for subsequent nutrient and COD/BOD analyses at the profiling locations.

## 2. Summary of Current Data

One Mini-Anderra recording current meter was installed on 24 June at 10:05 approximately 130 metres northwest of the fish cage operation (see Figure 1) and was set to record instantaneous direction and mean current speed at eight minute intervals. It was removed the following morning at 08:05. The meter was installed at approximately mid-depth in 17.3 metres of water with the impeller 8.0 m from the bed.. Two additional Mini-Anderra recording current meters were installed northwest of the fish cages on July 21 at 15:30 in 24.5 metres of water, one with the impeller 1.0 metre from the surface, and one with the impeller 15.5 metres from the surface. These meters were both removed on July 23 at 11:30.

Inspection of the data record from the deep current meter deployed in July revealed that nearly three quarters of the observations fell below the meter threshold of 2.0 cm $s^{-1}$ , rendering these

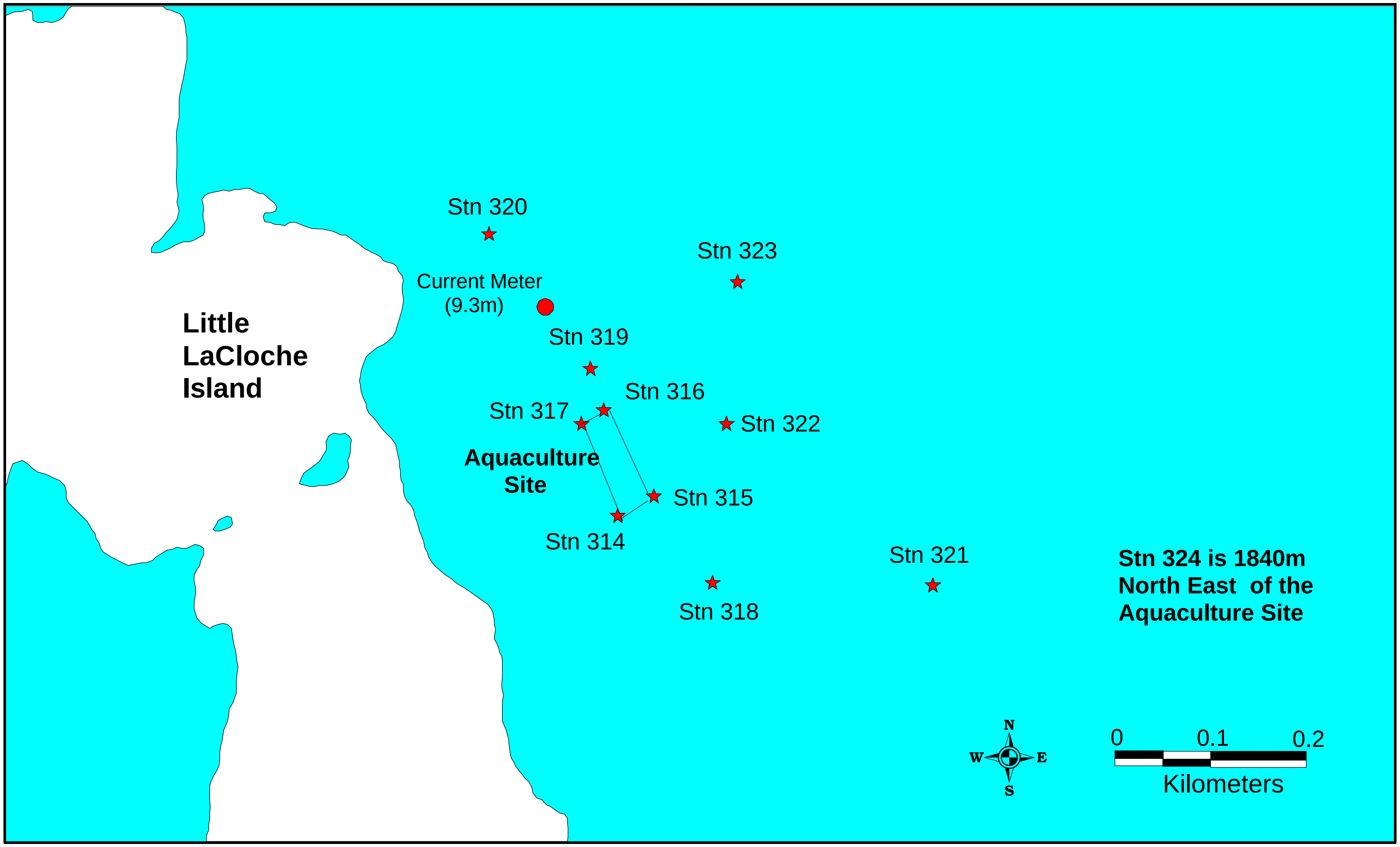


FIGURE 1: CURRENT METER AND SAMPLING STATION LOCATIONS NEAR EAGLE ROCK SITE

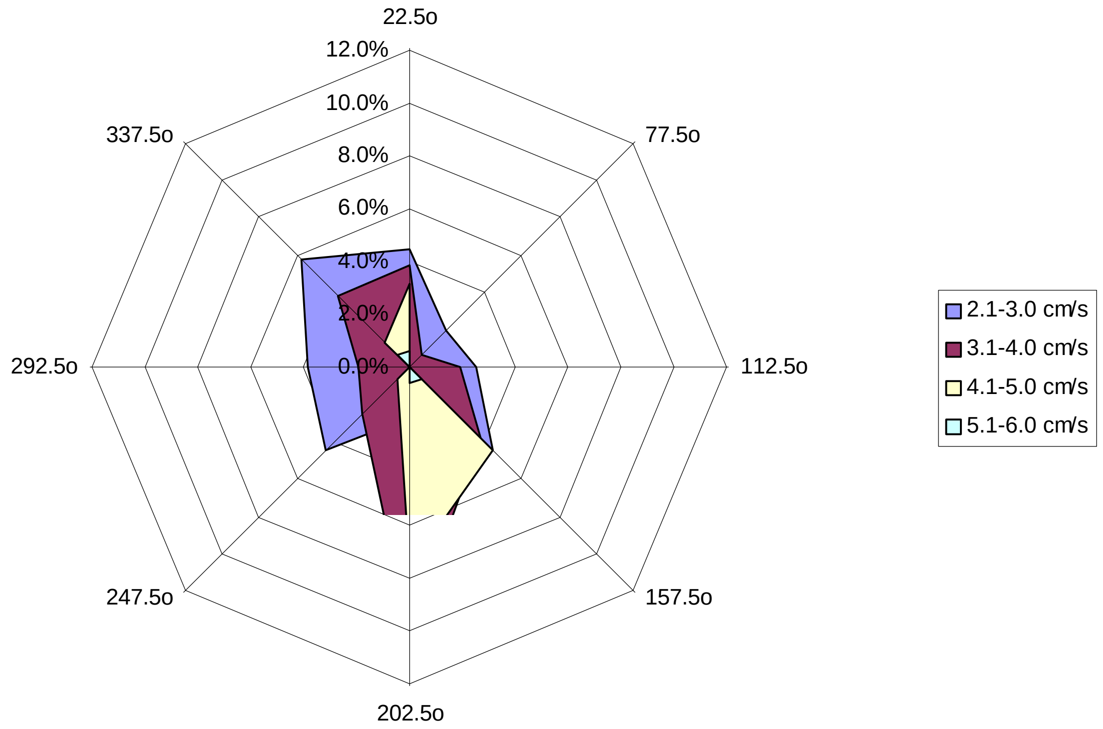
data of limited utility for subsequent calculations (although this observation is significant in and of itself). Results from the other two meters did not suffer from this limitation, however, and the data records are summarized in Tables 1 and 2, and Figures 2 to 5.

**TABLE 1: EAGLE ROCK SITE CURRENT METER RECORD SUMMARY FOR 24 AND 25 JUNE**

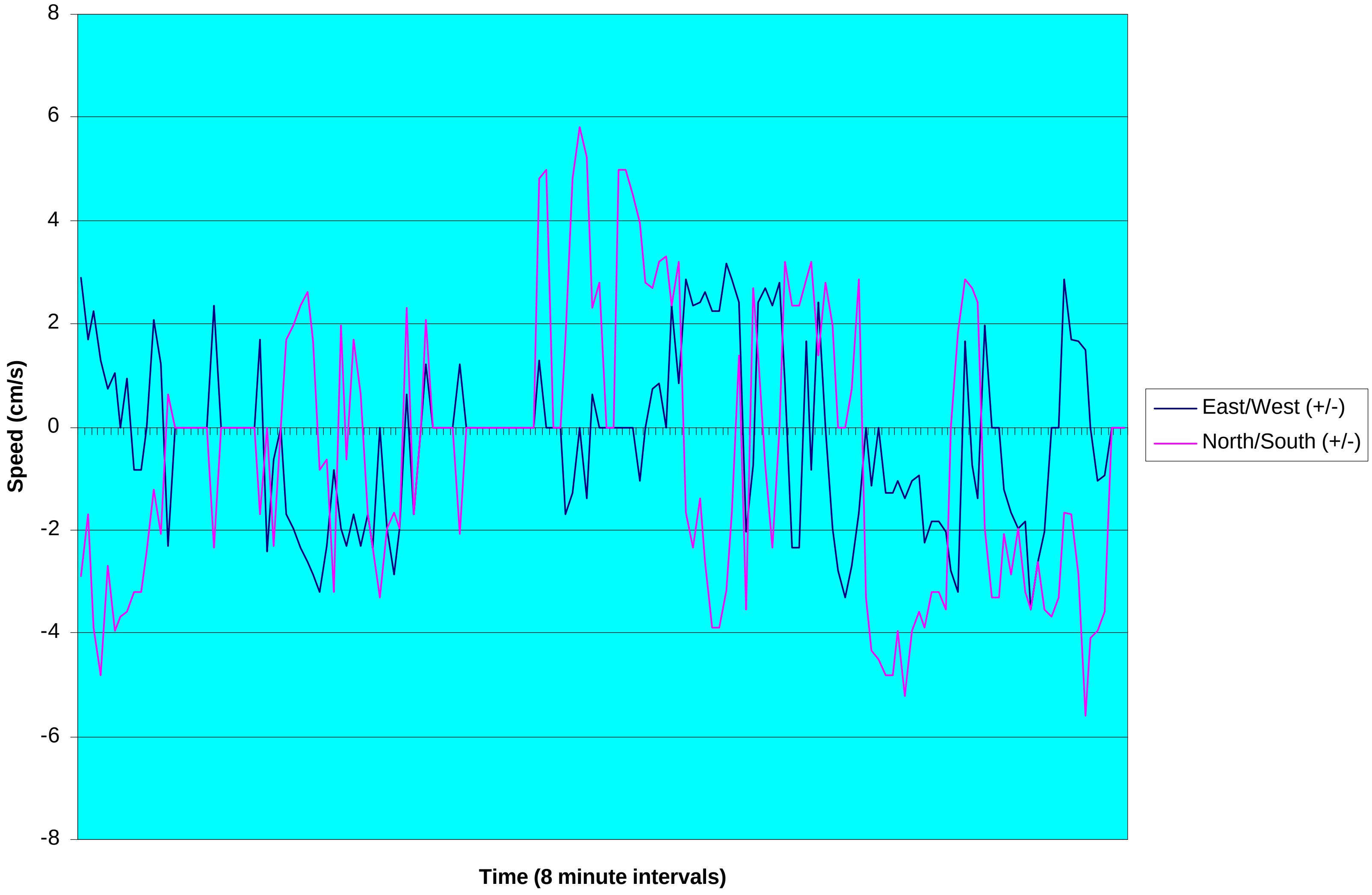
| **SPEED (cm/s)** | **DIRECTION (DEGREES MAGNETIC)** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **0-44** | **45-89** | **90-134** | **135-179** | **180-224** | **225-269** | **270-314** | **315-359** | **ROWSUM** |
| **<2** | | | | | | | | | 22.8% |
| **2.1-3.0** | 4.4% | 1.9% | 2.5% | 4.4% | 1.9% | 4.4% | 3.8% | 5.7% | 29.1% |
| **3.1-4.0** | 3.8% | 0.6% | 1.9% | 3.8% | 10.1% | 2.5% | 1.9% | 3.8% | 28.5% |
| **4.1-5.0** | 3.2% | 0.0% | 0.0% | 4.4% | 7.6% | 0.6% | 0.0% | 1.3% | 17.1% |
| **5.1-6.0** | 0.6% | 0.0% | 0.0% | 0.6% | 0.6% | 0.0% | 0.0% | 0.6% | 2.5% |
| **COLUMNSUM** | 12.0% | 2.5% | 4.4% | 13.3% | 20.3% | 7.6% | 5.7% | 11.4% | 100.0% |

Note: Summary of 158 eight-minute records over the period 10:52h, 24 June to 07:52h, 25 June in 17.3 m of water, 9.3 m from the surface

**FIGURE 2: EAGLE ROCK SITE CURRENT METER DIRECTION, SPEED AND FREQUENCY**



**SUMMARY FOR 24 AND 25 JUNE**



Note: Each stick (or dot) represents an eight minute record, current velocity resolved along N-S and E-W axes over the period 10:52 on 24 June through 7:52 on 25 June 1998

FIGURE 3: SUMMARY OF FLOWS NORTH OF EAGLE ROCK SITE ON 24-25 JUNE 1998

## TABLE 2: EAGLE ROCK SITE CURRENT METER RECORD SUMMARY FOR 21 TO 23 JULY

| SPEED (cm/s) | | | DIRECTION (DEGREES MAGNETIC) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **0-44** | **45-89** | **90-134** | **135-179** | **180-224** | **225-269** | **270-314** | **315-359** | **ROWSUM** |
| **<2** | | | | | | | | | 3.3% |
| **2.1-3.0** | 3.6% | 0.9% | 0.0% | 3.6% | 7.6% | 8.2% | 2.4% | 3.3% | 29.8% |
| **3.1-4.0** | 2.4% | 0.6% | 1.5% | 4.3% | 7.9% | 3.3% | 7.6% | 10.0% | 37.7% |
| **4.1-5.0** | 1.5% | 0.9% | 2.4% | 4.6% | 6.1% | 2.4% | 2.4% | 5.5% | 25.8% |
| **5.1-6.0** | 0.6% | 0.3% | 0.0% | 0.3% | 0.0% | 0.0% | 0.6% | 1.5% | 3.3% |
| **COLUMNSUM** | 8.2% | 2.7% | 4.0% | 12.8% | 21.6% | 14.0% | 13.1% | 20.4% | 100.0% |

Note: Summary of 329 eight-minute records over the period 15:35h, 21 July to 11:19h, 23 July in 24.5 m of water, 1.0 m from the surface

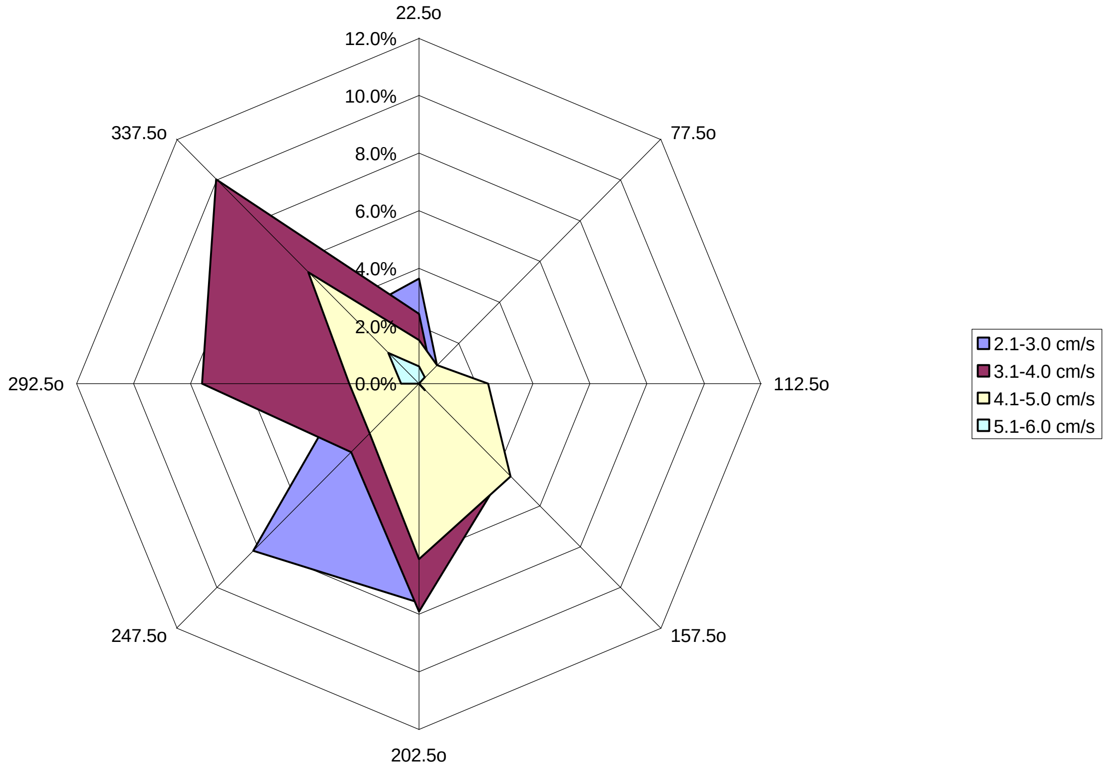
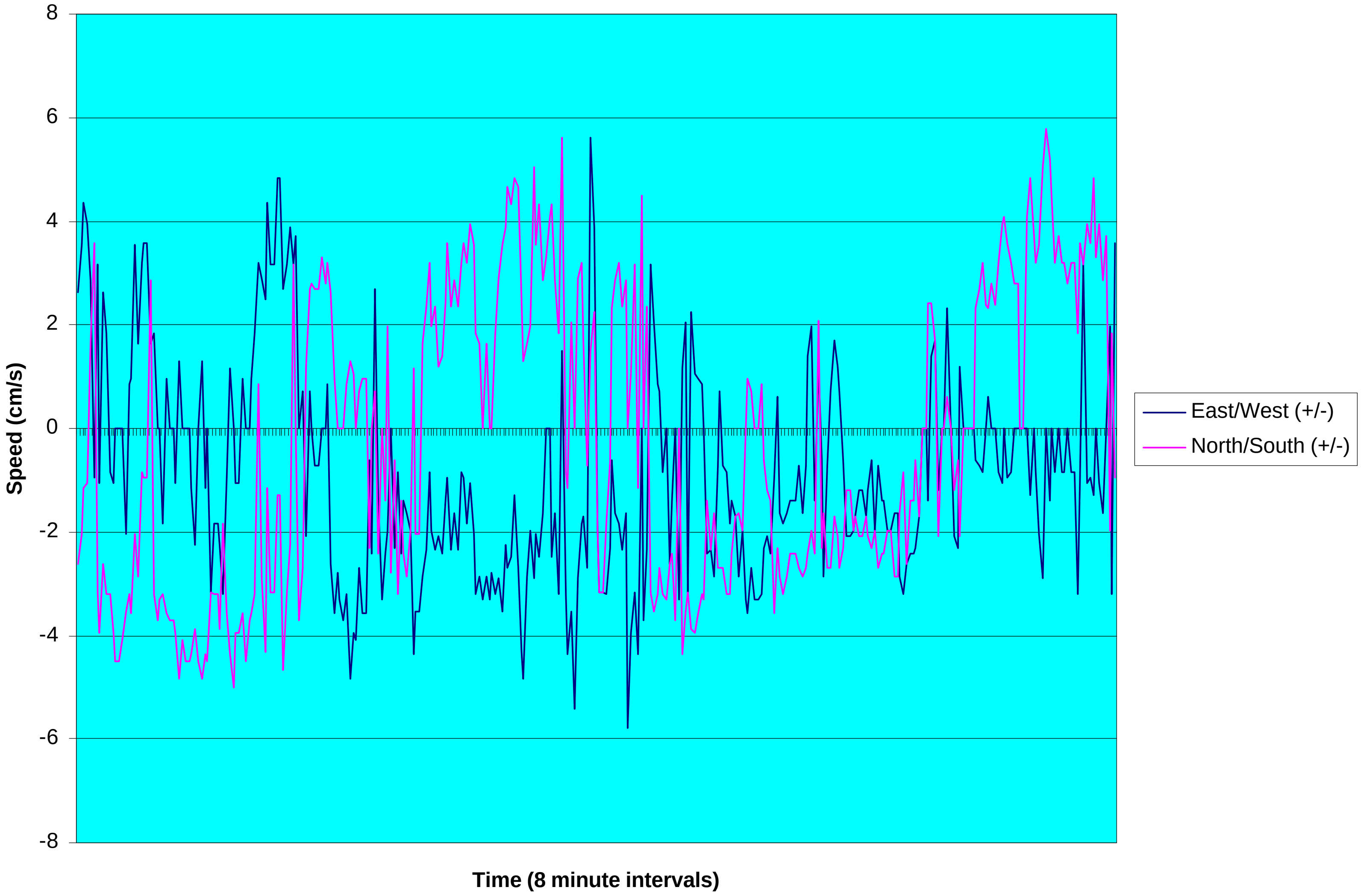


**FIGURE 4:** EAGLE ROCK SITE CURRENT METER DIRECTION, SPEED AND FREQUENCY SUMMARY FOR 21 TO 23 JULY



Note: Each point represents an eight minute record, current velocity resolved along N-S and E-W axes over the period 15:35 on 21 July through 11:19 on 23 July 1998

**FIGURE 5: SUMMARY OF FLOWS NORTH OF EAGLE ROCK SITE ON 21-23 JULY 1998**

Over the 21 hour period on June 24 and 25 current speeds 9.3 metres from the surface were consistently higher than the meter threshold of 2.0 cm $s^{-1}$ (77% of the time). Flow speeds seldom exceeded 5 cm $s^{-1}$, and flow directions covered all points of the compass with northerly (315-45°) and southerly (135-225°) flows accounting for about three quarters of the directional observations. Summing the velocities over the June period of record yields a net of 0.55 cm $s^{-1}$ in a southwesterly direction (204°).

A similar pattern was observed during the 44 hour period from July 21 to 23 with current speeds 1.0 metre from the surface exceeding the meter threshold of 2.0 cm $s^{-1}$ virtually all (97%) of the time . Once again, flow speeds seldom exceeded 5 cm $s^{-1}$, and flow directions covered all points of the compass with northerly (315-45°) and southerly (135-225°) flows accounting for about 65% of the directional observations. Summing these near-surface velocities over the July period of record yields a net of 0.9 cm $s^{-1}$ in a southwesterly direction (252°). The speed is somewhat higher than for the June record (which is to be expected given the difference in depths) but the general direction is similar, with flows to the southwest.

In addition to the data collected by stationary recording meters, current drogues were used to track current patterns at two depths on 24 June and 21 July over a six to eight hour period. In June, five drogues released 1.5 m from the surface moved steadily towards the northwest and north; the corresponding five drogues released at a depth of 8.0 m initially tended towards the southwest and then also moved towards the northwest. In July, the two drogues released 1.0 m from the surface moved towards the northwest, then north, and then swung sharply around to the east and southeast. The corresponding two drogues released 15.0 m from the surface moved more slowly, but progressed steadily towards the southeast and then east. The drogue drift patterns were consistent with the omnidirectional nature of the current meter record and the July result in particular clearly demonstrated the separate behaviour of the surface and subsurface water masses following stratification.

## 3. Summary of Profiling and Grab Sampling Data

Results of temperature, pH, conductivity, turbidity and dissolved oxygen (DO) profiling undertaken on July at (Stations 314 to 324) are summarized in Appendix 1. Profile results for temperature and DO are displayed graphically in Figures 6 and 7. These data were obtained using a Hydrolab DS3 unit with a Clark DO electrode (calibrated in air and tested under $N_2$). Results of surface, mid-depth, and near-bed samples collected with a Kemmerer sampler and analysed for nutrients and BOD/COD at these stations (according to MOE standard methods SBBOD-E3182A, RCOD-E3170A, RNDNP-E3364A, RTNP-E3367A) are presented in Appendix 2.

The profile data demonstrate the progress of thermal stratification and document slight hypolimnetic oxygen depletion above the thermocline in the immediate vicinity of the fish cages, although DO remained comfortably above the 6 mg/l PWQO for the protection of cold water fish habitat at all depths.

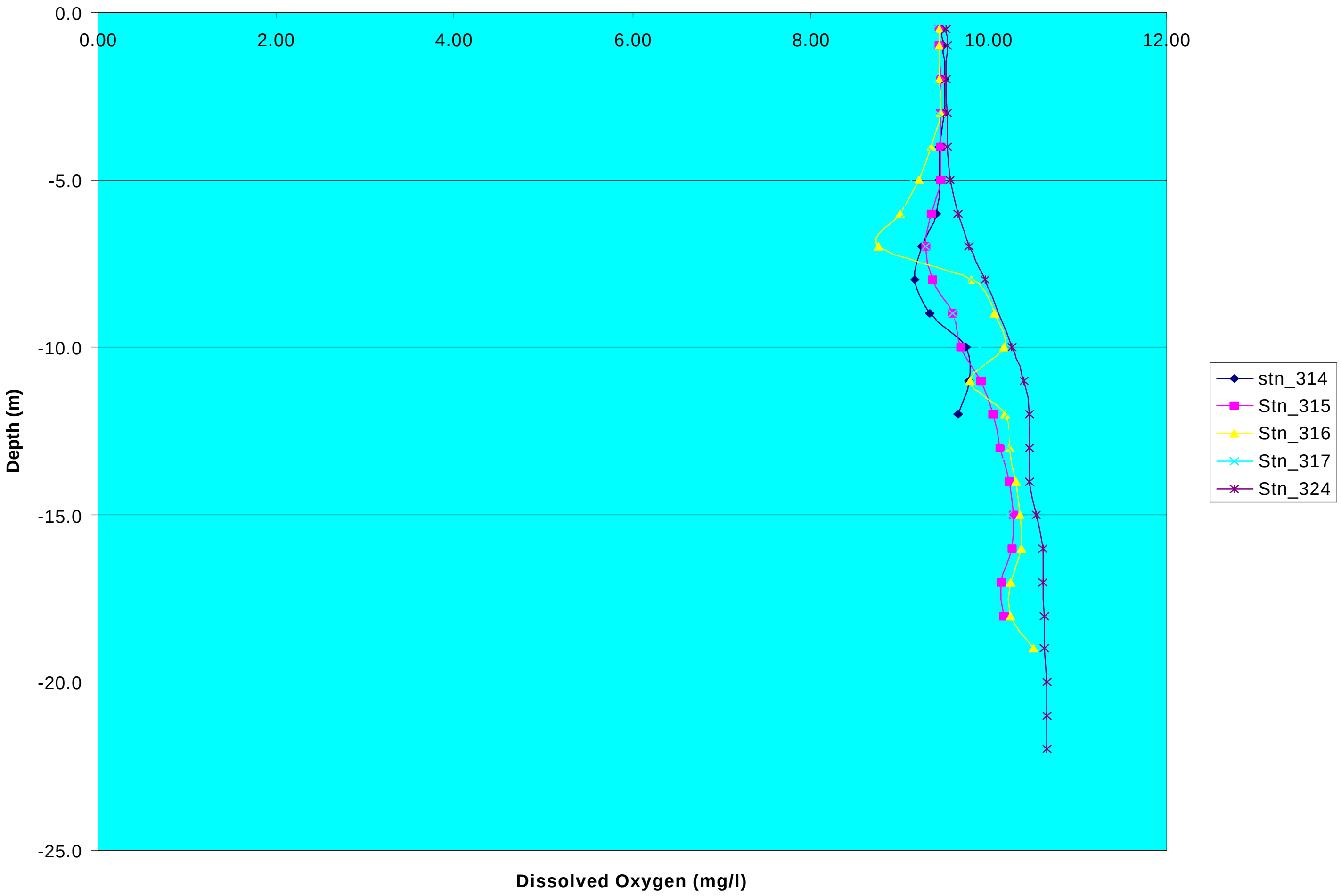


FIGURE 6: DISSOLVED OXYGEN PROFILE RESULTS (22 JULY 1998)

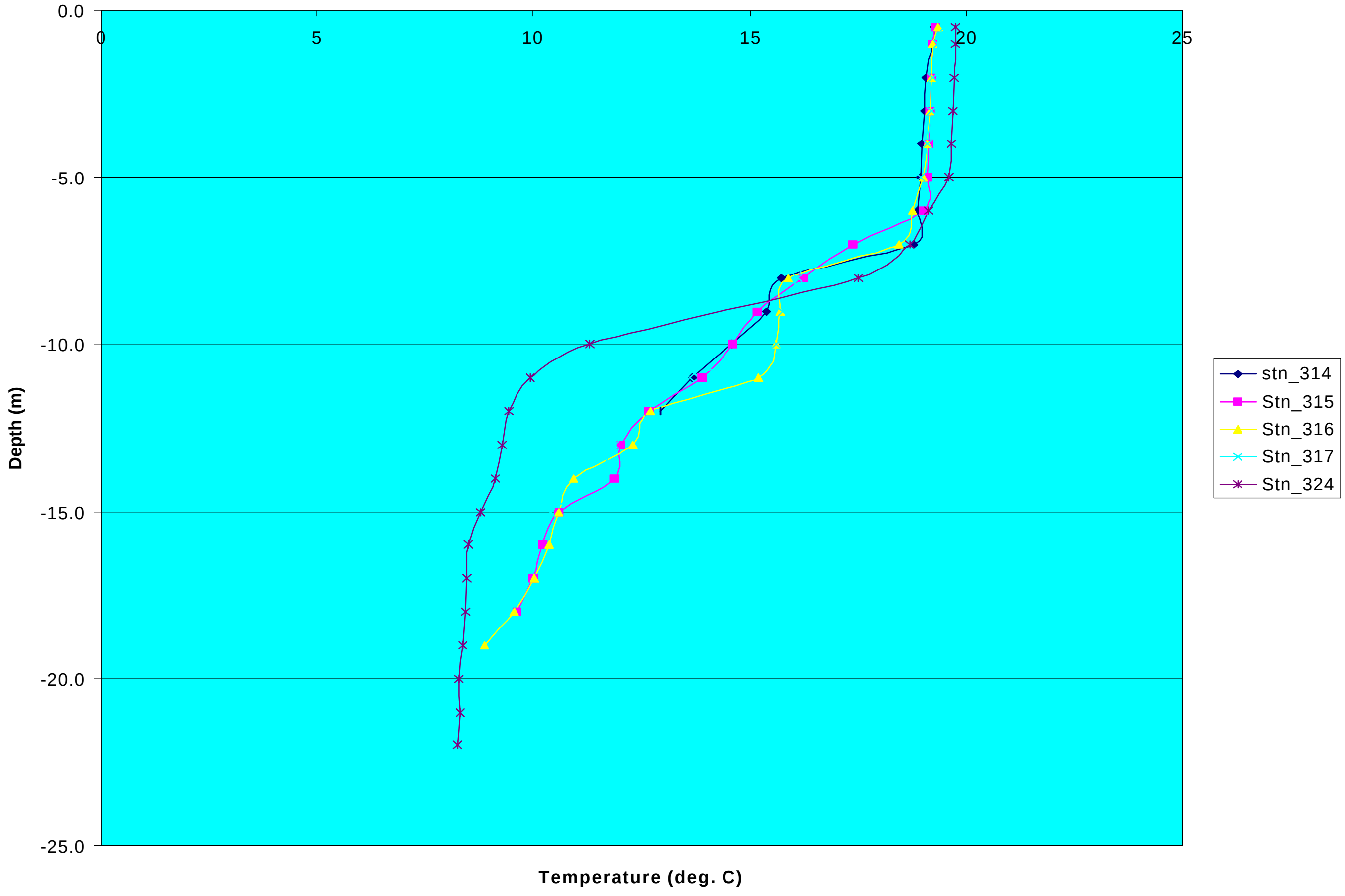


FIGURE 7: TEMPERATURE PROFILE RESULTS (22 JULY 1998)

The nutrient and BOD/COD results show similar concentrations and profiles at most stations (including Station 324: the local background reference station at the mouth of McGregor Bay) for all parameters other than phosphorus.  Both filtered reactive phosphate and total phosphorus data show an increasing gradient with depth in the vicinity of the fish cage operation which contrasts sharply with the situation at reference Station 324.  This pattern suggests that the existing operation has had a sufficient impact to result in localized algal growth followed by settling and decomposition.  In this case, however,  the increased oxygen demand associated with this process has had no discernable impact on hypolimnetic DO; presumably due to the unconfined nature of this site.

It is also worth noting that the background TP concentration was approximately 5 ug/litre and that surface concentrations of TP did not exceed this at any station.  On the other hand, sub-surface TP concentrations greater than the PWQO[1] of 10 ug/litre were detected at distances of approximately 200 metres from the fish cage operation (at Station 320 eleven metres from the surface and Station 323 approximately eight metres from the surface) and depth-averaged concentrations of TP greater than 10 ug/litre were detected as far as 100 metres from the fish cages (Station 318) as well as in their immediate vicinity (Stations 314, 315, and 317) .

## 4. Conclusions and Recommendations

(1) Water quality sampling provided evidence that operations at the Eagle Rock aquaculture site during the summer of 1998 resulted in localized nutrient (TP) enrichment and increased algal productivity although the unconfined nature of the site meant that this did not result in any DO depletion below the cold water PWQO of 6 mg litre$^{-1}$;

(2) Any definition of a “mixing zone” associated with this operation will need to take the vertical TP gradients into account -- we note that sub-surface and depth-averaged concentrations of TP greater than 10 ug litre$^{-1}$ were observed as far as 200m and 100m, respectively, from the fish cages;

(3) Current speeds in the epilimnion of 2-5 cm s$^{-1}$ were consistently observed in the vicinity of the fish cages with a slight predominance of southwesterly flows (although flows towards all points of the compass were observed) while  currents in the hypolimnion were independent from those in the epilimnion with speeds much lower than near the surface (nearly 75% of measurements were less than the  current meter threshold of 2 cm s$^{-1}$) ;

(4) These patterns of water movement imply that the impact zone of “effluent” from the fish cages will be largely determined by near-surface flows although increased concentrations of phosphorus following algal growth and settling will manifest themselves at mid-depth and near the bed;

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[1] To avoid nuisance concentrations of algae in lakes naturally below this value

# APPENDIX 1: EAGLE ROCK SITE PROFILING DATA FROM 22 JULY 1998

| | | Stn# 314.0 | | | | | | Stn# 315.0 | | | | | | Stn# 316.0 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Temp (Co) | pH | SpCond (uS/cm) | DO (%sat) | DO (mg/l) | Turb (NTU) | Temp (Co) | pH | SpCond (uS/cm) | DO (%sat) | DO (mg/l) | Turb (NTU) | Temp (Co) | pH | SpCond (uS/cm) | DO (%sat) | DO (mg/l) | Turb (NTU) |
| 0.5 | 19.3 | 8.1 | 185.0 | 103.4 | 9.5 | 0.0 | 19.3 | 8.2 | 184.0 | 103.1 | 9.5 | 0.0 | 19.4 | 8.2 | 183.0 | 103.2 | 9.5 | 0.0 |
| 1.0 | 19.2 | 8.1 | 185.0 | 103.4 | 9.5 | 0.0 | 19.2 | 8.2 | 184.0 | 103.1 | 9.5 | 0.0 | 19.2 | 8.2 | 183.0 | 103.0 | 9.5 | 0.0 |
| 2.0 | 19.1 | 8.2 | 184.0 | 103.4 | 9.5 | 0.0 | 19.2 | 8.2 | 184.0 | 103.0 | 9.5 | 0.0 | 19.2 | 8.2 | 183.0 | 103.0 | 9.5 | 0.0 |
| 3.0 | 19.0 | 8.2 | 184.0 | 103.3 | 9.5 | 0.0 | 19.2 | 8.2 | 184.0 | 103.0 | 9.5 | 0.0 | 19.2 | 8.2 | 183.0 | 102.9 | 9.5 | 0.0 |
| 4.0 | 19.0 | 8.2 | 184.0 | 102.4 | 9.4 | 0.0 | 19.1 | 8.2 | 184.0 | 103.0 | 9.5 | 0.0 | 19.1 | 8.2 | 183.0 | 101.6 | 9.4 | 0.0 |
| 5.0 | 19.0 | 8.2 | 184.0 | 102.4 | 9.4 | 0.0 | 19.1 | 8.2 | 183.0 | 102.9 | 9.5 | 0.0 | 19.0 | 8.2 | 184.0 | 100.0 | 9.2 | 0.0 |
| 6.0 | 18.9 | 8.2 | 184.0 | 101.8 | 9.4 | 0.0 | 19.0 | 8.2 | 184.0 | 101.5 | 9.4 | 0.0 | 18.8 | 8.2 | 184.0 | 97.2 | 9.0 | 0.0 |
| 7.0 | 18.8 | 8.2 | 184.0 | 99.8 | 9.2 | 0.0 | 17.4 | 8.1 | 185.0 | 97.5 | 9.3 | 0.2 | 18.5 | 8.1 | 184.0 | 94.0 | 8.8 | 0.0 |
| 8.0 | 15.7 | 8.0 | 184.0 | 93.0 | 9.2 | 0.4 | 16.2 | 8.1 | 185.0 | 96.1 | 9.4 | 0.4 | 15.9 | 8.1 | 184.0 | 99.8 | 9.8 | 0.6 |
| 9.0 | 15.4 | 8.0 | 184.0 | 93.9 | 9.3 | 0.5 | 15.2 | 8.0 | 184.0 | 96.0 | 9.6 | 0.6 | 15.7 | 8.1 | 183.0 | 101.9 | 10.1 | 0.8 |
| 10.0 | 14.6 | 8.0 | 184.0 | 96.5 | 9.8 | 0.2 | 14.6 | 8.0 | 184.0 | 95.9 | 9.7 | 0.8 | 15.6 | 8.1 | 183.0 | 102.9 | 10.2 | 1.0 |
| 11.0 | 13.7 | 7.9 | 184.0 | 94.8 | 9.8 | 1.1 | 13.9 | 8.0 | 184.0 | 96.6 | 9.9 | 0.7 | 15.2 | 8.0 | 183.0 | 98.2 | 9.8 | 1.0 |
| 12.0 | 12.9 | 7.9 | 183.0 | 92.1 | 9.7 | 4.8 | 12.7 | 7.9 | 184.0 | 95.3 | 10.1 | 1.0 | 12.7 | 8.0 | 183.0 | 96.7 | 10.2 | 1.2 |
| 13.0 | | | | | | | 12.0 | 7.9 | 184.0 | 94.6 | 10.1 | 1.3 | 12.3 | 8.0 | 184.0 | 96.2 | 10.2 | 1.4 |
| 14.0 | | | | | | | 11.9 | 7.9 | 184.0 | 95.2 | 10.2 | 1.3 | 10.9 | 8.0 | 185.0 | 93.8 | 10.3 | 1.4 |
| 15.0 | | | | | | | 10.6 | 7.9 | 184.0 | 92.9 | 10.3 | 1.2 | 10.6 | 7.9 | 184.0 | 93.6 | 10.4 | 1.5 |
| 16.0 | | | | | | | 10.2 | 7.8 | 184.0 | 92.0 | 10.3 | 1.3 | 10.4 | 7.9 | 184.0 | 93.3 | 10.4 | 1.4 |
| 17.0 | | | | | | | 10.0 | 7.8 | 185.0 | 90.5 | 10.1 | 1.5 | 10.0 | 7.9 | 184.0 | 91.4 | 10.3 | 1.6 |
| 18.0 | | | | | | | 9.6 | 7.7 | 184.0 | 89.8 | 10.2 | 1.4 | 9.6 | 7.9 | 184.0 | 90.5 | 10.3 | 1.8 |
| 19.0 | | | | | | | | | | | | | 8.9 | 7.8 | 184.0 | 91.1 | 10.5 | 1.7 |

| | | | Stn# 317.0 | | | | | | Stn# 318.0 | | | | | | Stn# 319.0 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Temp (Co) | pH | SpCond (uS/cm) | DO (%sat) | DO (mg/l) | Turb (NTU) | Temp (Co) | pH | SpCond (uS/cm) | DO (%sat) | DO (mg/l) | Turb (NTU) | Temp (Co) | pH | SpCond (uS/cm) | DO (%sat) | DO (mg/l) | Turb (NTU) |
| 0.5 | 19.5 | 8.2 | 184.0 | 102.6 | 9.4 | 0.1 | 19.5 | 8.2 | 184.0 | 93.1 | 8.5 | 10.8 | 19.7 | 8.2 | 183.0 | 103.6 | 9.4 | 1.3 |
| 1.0 | 19.4 | 8.2 | 184.0 | 101.5 | 9.3 | 0.1 | 19.5 | 8.2 | 184.0 | 97.9 | 8.9 | 0.0 | 19.5 | 8.2 | 183.0 | 103.2 | 9.4 | 1.3 |
| 2.0 | 19.2 | 8.2 | 183.0 | 102.0 | 9.4 | 0.1 | 19.2 | 8.2 | 183.0 | 96.5 | 8.8 | 0.0 | 19.3 | 8.2 | 183.0 | 103.4 | 9.5 | 1.4 |
| 3.0 | 19.2 | 8.2 | 183.0 | 102.7 | 9.4 | 0.2 | 19.2 | 8.2 | 183.0 | 98.2 | 9.0 | 0.0 | 19.3 | 8.2 | 183.0 | 103.4 | 9.5 | 1.4 |
| 4.0 | 19.1 | 8.2 | 183.0 | 101.2 | 9.3 | 0.3 | 19.1 | 8.2 | 183.0 | 94.7 | 8.7 | 0.0 | 18.9 | 8.2 | 183.0 | 101.8 | 9.4 | 1.3 |
| 5.0 | 19.0 | 8.2 | 184.0 | 99.0 | 9.1 | 0.3 | 18.5 | 8.2 | 183.0 | 92.2 | 8.6 | 0.0 | 18.0 | 8.1 | 183.0 | 95.5 | 9.0 | 1.3 |
| 6.0 | 18.5 | 8.1 | 184.0 | 97.5 | 9.1 | 0.3 | 17.8 | 8.1 | 183.0 | 90.2 | 8.5 | 0.1 | 17.1 | 8.1 | 183.0 | 99.5 | 9.5 | 1.6 |
| 7.0 | 16.7 | 8.1 | 184.0 | 96.1 | 9.3 | 0.7 | 16.0 | 8.1 | 183.0 | 93.6 | 9.2 | 0.5 | 16.4 | 8.1 | 183.0 | 103.3 | 10.0 | 1.6 |
| 8.0 | 16.1 | 8.0 | 184.0 | 100.1 | 9.8 | 1.1 | 15.8 | 8.0 | 183.0 | 92.1 | 9.1 | 0.5 | 15.9 | 8.1 | 183.0 | 103.0 | 10.1 | 1.5 |
| 9.0 | 15.8 | 8.0 | 184.0 | 97.3 | 9.6 | 1.3 | 15.3 | 8.0 | 183.0 | 92.2 | 9.2 | 0.7 | 15.5 | 8.0 | 183.0 | 97.9 | 9.7 | 1.5 |
| 10.0 | 15.6 | 8.0 | 183.0 | 100.1 | 9.9 | 1.3 | 15.1 | 8.0 | 183.0 | 97.4 | 9.7 | 0.8 | 14.4 | 8.0 | 183.0 | 97.4 | 9.9 | 1.4 |
| 11.0 | 13.6 | 8.0 | 183.0 | 97.0 | 10.0 | 1.3 | 13.7 | 8.0 | 184.0 | 94.2 | 9.7 | 1.1 | 13.4 | 7.9 | 183.0 | 99.3 | 10.3 | 1.7 |
| 12.0 | 12.0 | 8.0 | 184.0 | 95.5 | 10.2 | 1.6 | 12.6 | 7.9 | 183.0 | 87.1 | 9.2 | 1.3 | 12.4 | 7.9 | 183.0 | 95.9 | 10.2 | 2.1 |
| 13.0 | 11.9 | 7.9 | 184.0 | 95.1 | 10.2 | 1.7 | 11.8 | 7.9 | 184.0 | 86.6 | 9.3 | 1.2 | 11.3 | 7.9 | 184.0 | 94.5 | 10.3 | 1.9 |
| 14.0 | 11.4 | 7.9 | 184.0 | 92.7 | 10.1 | 1.5 | 11.7 | 7.8 | 183.0 | 90.7 | 9.8 | 1.4 | 10.7 | 7.8 | 184.0 | 92.7 | 10.2 | 1.9 |
| 15.0 | 10.4 | 7.9 | 184.0 | 92.0 | 10.2 | 1.7 | 10.9 | 7.8 | 184.0 | 89.2 | 9.8 | 1.4 | 10.3 | 7.8 | 184.0 | 91.9 | 10.2 | 1.8 |
| 16.0 | | | | | | | 10.9 | 7.8 | 184.0 | 86.6 | 9.5 | 1.2 | 10.1 | 7.8 | 184.0 | 91.8 | 10.3 | 1.8 |
| 17.0 | | | | | | | 10.5 | 7.7 | 184.0 | 87.1 | 9.7 | 1.4 | 9.8 | 7.8 | 184.0 | 91.4 | 10.3 | 1.8 |
| 18.0 | | | | | | | 10.4 | 7.7 | 184.0 | 86.4 | 9.6 | 2.1 | 9.4 | 7.8 | 184.0 | 90.5 | 10.3 | 2.0 |
| 19.0 | | | | | | | | | | | | | | | | | | |

|  | Stn# 320.0 |  |  |  |  |  | Stn# 322.0 |  |  |  |  |  | Stn# 323.0 |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Temp (Co) | pH | SpCond (uS/cm) | DO (%sat) | DO (mg/l) | Turb (NTU) | Temp (Co) | pH | SpCond (uS/cm) | DO (%sat) | DO (mg/l) | Turb (NTU) | Temp (Co) | pH | SpCond (uS/cm) | DO (%sat) | DO (mg/l) | Turb (NTU) |
| 0.5 | 19.6 | 8.2 | 183.0 | 103.7 | 9.5 | 0.0 | 19.6 | 8.2 | 184.0 | 105.1 | 9.6 | 6.7 | 19.7 | 8.2 | 184.0 | 104.3 | 9.5 | 0.1 |
| 1.0 | 19.4 | 8.2 | 183.0 | 103.2 | 9.5 | 0.0 | 19.5 | 8.2 | 184.0 | 104.4 | 9.5 | 1.6 | 19.7 | 8.2 | 184.0 | 104.2 | 9.5 | 0.1 |
| 2.0 | 19.1 | 8.2 | 183.0 | 102.8 | 9.5 | 0.0 | 19.3 | 8.2 | 184.0 | 104.8 | 9.6 | 1.5 | 19.7 | 8.2 | 183.0 | 104.4 | 9.5 | 0.0 |
| 3.0 | 19.1 | 8.2 | 183.0 | 102.8 | 9.5 | 0.0 | 18.5 | 8.2 | 184.0 | 104.7 | 9.8 | 1.4 | 19.0 | 8.2 | 184.0 | 104.1 | 9.6 | 0.2 |
| 4.0 | 18.9 | 8.2 | 183.0 | 103.6 | 9.6 | 0.1 | 17.9 | 8.2 | 184.0 | 103.2 | 9.7 | 1.3 | 17.8 | 8.2 | 184.0 | 104.7 | 9.9 | 0.5 |
| 5.0 | 18.6 | 8.1 | 183.0 | 97.5 | 9.1 | 0.1 | 17.4 | 8.1 | 184.0 | 99.7 | 9.5 | 1.2 | 17.0 | 8.2 | 184.0 | 104.6 | 10.0 | 0.8 |
| 6.0 | 17.4 | 8.1 | 183.0 | 103.1 | 9.8 | 0.4 | 16.0 | 8.1 | 183.0 | 105.1 | 10.3 | 1.3 | 16.1 | 8.2 | 184.0 | 105.1 | 10.3 | 1.0 |
| 7.0 | 16.9 | 8.1 | 183.0 | 104.3 | 10.0 | 0.5 | 15.6 | 8.1 | 183.0 | 103.1 | 10.2 | 1.4 | 15.8 | 8.1 | 183.0 | 104.9 | 10.3 | 1.1 |
| 8.0 | 16.2 | 8.1 | 183.0 | 102.3 | 10.0 | 0.8 | 15.0 | 8.0 | 183.0 | 101.4 | 10.2 | 1.3 | 13.8 | 8.1 | 184.0 | 101.5 | 10.4 | 1.4 |
| 9.0 | 15.5 | 8.1 | 183.0 | 101.5 | 10.1 | 0.9 | 12.8 | 8.0 | 183.0 | 98.6 | 10.4 | 1.7 | 13.1 | 8.0 | 183.0 | 98.7 | 10.3 | 1.7 |
| 10.0 | 14.4 | 8.0 | 183.0 | 98.8 | 10.0 | 1.4 | 12.2 | 7.9 | 183.0 | 96.2 | 10.3 | 1.9 | 12.2 | 8.0 | 184.0 | 96.1 | 10.2 | 1.8 |
| 11.0 | 12.5 | 7.9 | 183.0 | 96.6 | 10.2 | 2.0 | 11.9 | 7.9 | 183.0 | 95.5 | 10.3 | 1.9 | 11.8 | 7.9 | 183.0 | 95.4 | 10.3 | 1.9 |
| 12.0 | 12.2 | 7.9 | 183.0 | 95.4 | 10.2 | 1.8 | 11.6 | 7.8 | 183.0 | 94.7 | 10.2 | 1.4 | 11.4 | 7.9 | 184.0 | 94.7 | 10.3 | 1.6 |
| 13.0 | 11.5 | 7.8 | 183.0 | 94.0 | 10.2 | 1.9 | 10.7 | 7.8 | 184.0 | 93.6 | 10.3 | 1.3 | 10.8 | 7.9 | 184.0 | 93.8 | 10.3 | 2.0 |
| 14.0 |  |  |  |  |  |  | 10.2 | 7.8 | 184.0 | 93.3 | 10.4 | 1.4 | 10.5 | 7.8 | 184.0 | 93.3 | 10.3 | 1.5 |
| 15.0 |  |  |  |  |  |  | 10.1 | 7.8 | 184.0 | 92.9 | 10.4 | 1.3 | 10.0 | 7.8 | 184.0 | 92.8 | 10.4 | 1.7 |
| 16.0 |  |  |  |  |  |  | 9.8 | 7.8 | 184.0 | 92.3 | 10.4 | 1.4 | 9.5 | 7.8 | 185.0 | 92.4 | 10.5 | 1.8 |
| 17.0 |  |  |  |  |  |  | 9.6 | 7.8 | 184.0 | 92.1 | 10.4 | 1.5 | 9.2 | 7.8 | 185.0 | 92.2 | 10.5 | 1.7 |
| 18.0 |  |  |  |  |  |  | 9.4 | 7.8 | 184.0 | 91.7 | 10.4 | 1.4 | 9.2 | 7.8 | 185.0 | 91.9 | 10.5 | 1.7 |
| 19.0 |  |  |  |  |  |  | 9.3 | 7.8 | 184.0 | 91.9 | 10.5 | 1.4 | 9.1 | 7.8 | 184.0 | 91.8 | 10.5 | 1.9 |
| 20.0 |  |  |  |  |  |  | 9.1 | 7.8 | 184.0 | 91.7 | 10.5 | 1.6 | 9.0 | 7.8 | 185.0 | 91.5 | 10.5 | 1.8 |
| 21.0 |  |  |  |  |  |  | 9.0 | 7.8 | 184.0 | 91.7 | 10.5 | 1.7 | 8.9 | 7.8 | 184.0 | 91.3 | 10.5 | 2.0 |
| 22.0 |  |  |  |  |  |  | 9.0 | 7.8 | 184.0 | 91.6 | 10.5 | 1.7 | 8.9 | 7.8 | 185.0 | 91.2 | 10.5 | 2.0 |
| 23.0 |  |  |  |  |  |  | 9.0 | 7.7 | 184.0 | 91.6 | 10.5 | 1.5 | 8.8 | 7.8 | 185.0 | 91.0 | 10.5 | 2.1 |
| 24.0 |  |  |  |  |  |  | 9.0 | 7.7 | 184.0 | 91.4 | 10.5 | 1.2 | 8.8 | 7.8 | 184.0 | 91.0 | 10.5 | 2.2 |
| 25.0 |  |  |  |  |  |  | 9.0 | 7.7 | 184.0 | 91.1 | 10.5 | 1.5 | 8.8 | 7.8 | 184.0 | 90.8 | 10.5 | 2.1 |
| 26.0 |  |  |  |  |  |  | 8.9 | 7.8 | 185.0 | 90.6 | 10.4 | 4.7 | 8.7 | 7.8 | 184.0 | 90.7 | 10.5 | 2.2 |

Stn# 324.0

| Depth (m) | Temp (Co) | pH | SpCond (uS/cm) | DO (%sat) | DO (mg/l) | Turb (NTU) |
|---|---|---|---|---|---|---|
| 0.5 | 19.8 | 8.2 | 183.0 | 104.9 | 9.5 | 0.0 |
| 1.0 | 19.8 | 8.2 | 183.0 | 105.0 | 9.5 | 0.0 |
| 2.0 | 19.7 | 8.2 | 183.0 | 104.9 | 9.5 | 0.0 |
| 3.0 | 19.7 | 8.2 | 183.0 | 104.8 | 9.5 | 0.0 |
| 4.0 | 19.7 | 8.2 | 183.0 | 104.8 | 9.5 | 0.0 |
| 5.0 | 19.6 | 8.2 | 183.0 | 105.0 | 9.6 | 0.0 |
| 6.0 | 19.1 | 8.2 | 183.0 | 105.0 | 9.7 | 0.1 |
| 7.0 | 18.7 | 8.2 | 183.0 | 105.4 | 9.8 | 0.2 |
| 8.0 | 17.5 | 8.2 | 183.0 | 104.7 | 10.0 | 0.5 |
| 10.0 | 11.3 | 8.0 | 183.0 | 94.4 | 10.3 | 2.0 |
| 11.0 | 9.9 | 7.9 | 184.0 | 92.6 | 10.4 | 2.5 |
| 12.0 | 9.4 | 7.9 | 184.0 | 92.0 | 10.5 | 2.1 |
| 13.0 | 9.3 | 7.8 | 184.0 | 91.7 | 10.5 | 2.1 |
| 14.0 | 9.1 | 7.8 | 184.0 | 91.4 | 10.5 | 2.0 |
| 15.0 | 8.8 | 7.8 | 184.0 | 91.2 | 10.5 | 2.0 |
| 16.0 | 8.5 | 7.8 | 185.0 | 91.3 | 10.6 | 2.6 |
| 17.0 | 8.5 | 7.8 | 185.0 | 91.2 | 10.6 | 2.3 |
| 18.0 | 8.4 | 7.8 | 185.0 | 91.2 | 10.6 | 2.2 |
| 19.0 | 8.4 | 7.8 | 185.0 | 91.2 | 10.6 | 2.3 |
| 20.0 | 8.3 | 7.8 | 184.0 | 91.2 | 10.7 | 2.3 |
| 21.0 | 8.3 | 7.8 | 185.0 | 91.2 | 10.7 | 2.4 |
| 22.0 | 8.3 | 7.8 | 185.0 | 91.1 | 10.7 | 2.6 |

## APPENDIX 2: EAGLE ROCK SITE WATER QUALITY DATA FROM 22 JULY 1998

| STN.# | DATE | STN DEPTH | SAMP DEP | COD(MG/L) | | BOD(MG/L) | | NNHTUR(MG/L) | | NN02UR(MG/L) | | NNOTUR(MG/L) | | PPO4FR(MG/L) | | PPUT(MG/L) | | NNTKUR(MG/L) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 314 | 980722 | 12.7 | 1.5 | 7.0 | | 0.6 | <T | 0.004 | <T | 0.001 | <W | 0.165 | | 0.0005 | <W | 0.004 | <T | 0.18 | |
| 314 | 980722 | 12.7 | 8.0 | 5.0 | | 0.6 | <T | 0.012 | | 0.001 | <W | 0.185 | | 0.0010 | <T | 0.014 | | 0.20 | |
| 314 | 980722 | 12.7 | 11.0 | 5.0 | | 1.0 | | 0.016 | | 0.002 | <T | 0.200 | | 0.0010 | <T | 0.016 | | 0.24 | |
| 315 | 980722 | 18.7 | 1.5 | 4.0 | <T | 0.6 | <T | 0.006 | <T | 0.002 | <T | 0.170 | | 0.0005 | <W | 0.002 | <W | 0.18 | |
| 315 | 980722 | 18.7 | 8.0 | 3.0 | <T | 1.0 | <T | 0.016 | | 0.003 | <T | 0.185 | | 0.0005 | <W | 0.004 | <T | 0.20 | |
| 315 | 980722 | 18.8 | 17.5 | 11.0 | | 2.2 | | 0.002 | <W | 0.008 | | 0.245 | | 0.0335 | | 0.066 | | 0.24 | |
| 316 | 980722 | 19.5 | 1.5 | 10.0 | | 0.8 | <T | 0.002 | <W | 0.002 | <T | 0.165 | | 0.0010 | <T | 0.006 | <T | 0.22 | |
| 316 | 980722 | 19.5 | 9.0 | 11.0 | | 1.0 | <T | 0.002 | <W | 0.002 | <T | 0.190 | | 0.0005 | <W | 0.008 | <T | 0.20 | |
| 316 | 980722 | 19.5 | 18.0 | 3.0 | <T | 1.2 | | 0.004 | <T | 0.008 | | 0.255 | | 0.0010 | <T | 0.008 | <T | 0.18 | |
| 317 | 980722 | 15.3 | 1.5 | 4.0 | <T | 0.8 | <T | 0.004 | <T | 0.003 | <T | 0.170 | | 0.0005 | <W | 0.004 | <T | 0.28 | |
| 317 | 980722 | 15.3 | 9.0 | 10.0 | | 1.0 | | 0.010 | | 0.002 | <T | 0.180 | | 0.0010 | <T | 0.002 | <W | 0.20 | |
| 317 | 980722 | 15.4 | 14.0 | 4.0 | <T | 1.2 | | 0.002 | <W | 0.003 | <T | 0.225 | | 0.0070 | | 0.024 | | 0.20 | |
| 318 | 980722 | 19.3 | 1.5 | 5.0 | | 0.6 | <T | 0.002 | <W | 0.002 | <T | 0.170 | | 0.0005 | <W | 0.002 | <W | 0.20 | |
| 318 | 980722 | 17.5 | 11.0 | 11.0 | | 1.2 | | 0.012 | | 0.002 | <T | 0.215 | | 0.0005 | <W | 0.010 | | 0.24 | |
| 318 | 980722 | 17.5 | 16.0 | 7.0 | | 1.6 | | 0.002 | <W | 0.005 | | 0.255 | | 0.0080 | | 0.026 | | 0.20 | |
| 319 | 980722 | 20.5 | 1.5 | 5.0 | | 0.8 | <T | 0.002 | <W | 0.002 | <T | 0.170 | | 0.0005 | <W | 0.008 | <T | 0.20 | |
| 319 | 980722 | 21.0 | 12.0 | 3.0 | <T | 1.2 | | 0.008 | <T | 0.003 | <T | 0.225 | | 0.0005 | <W | 0.012 | | 0.24 | |
| 319 | 980722 | 20.0 | 19.0 | 7.0 | | 1.2 | | 0.008 | <T | 0.007 | | 0.270 | | 0.0005 | <W | 0.006 | <T | 0.16 | |
| 320 | 980722 | 14.4 | 1.5 | 3.0 | <T | 1.0 | <T | 0.008 | <T | 0.002 | <T | 0.175 | | 0.0005 | <W | 0.008 | <T | 0.20 | |
| 320 | 980722 | 14.1 | 11.0 | 3.0 | <T | 1.2 | | 0.018 | | 0.002 | <T | 0.200 | | 0.0005 | <W | 0.014 | | 0.32 | |
| 321 | 980722 | 34.5 | 1.5 | 4.0 | <T | 1.0 | | 0.004 | <T | 0.002 | <T | 0.170 | | 0.0005 | <W | 0.006 | <T | 0.24 | |
| 321 | 980722 | 34.9 | 10.5 | 4.0 | <T | 1.0 | | 0.010 | | 0.003 | <T | 0.215 | | 0.0005 | <W | 0.006 | <T | 0.20 | |
| 321 | 980722 | 35.1 | 33.5 | 2.0 | <T | 0.8 | <T | 0.008 | <T | 0.009 | | 0.295 | | 0.0010 | <T | 0.006 | <T | 0.16 | |
| 322 | 980722 | 25.5 | 1.5 | 6.0 | | 1.0 | <T | 0.008 | <T | 0.002 | <T | 0.175 | | 0.0005 | <W | 0.006 | <T | 0.22 | |
| 322 | 980722 | 25.5 | 9.0 | 13.0 | | 1.4 | | 0.018 | | 0.002 | <T | 0.215 | | 0.0010 | <T | 0.006 | <T | 0.22 | |
| 322 | 980722 | 25.5 | 24.0 | 3.0 | <T | 1.0 | | 0.006 | <T | 0.008 | | 0.280 | | 0.0005 | <W | 0.006 | <T | 0.16 | |
| 323 | 980722 | 27.0 | 1.5 | 4.0 | <T | 1.4 | | 0.004 | <T | 0.002 | <T | 0.170 | | 0.0005 | <W | 0.006 | <T | 0.22 | |
| 323 | 980722 | 27.0 | 8.5 | 8.0 | | 1.2 | | 0.012 | | 0.002 | <T | 0.215 | | 0.0005 | <W | 0.012 | | 0.26 | |
| 323 | 980722 | 27.0 | 25.5 | 5.0 | | 0.8 | <T | 0.008 | <T | 0.009 | | 0.290 | | 0.0005 | <W | 0.006 | <T | 0.18 | |
| 324 | 980722 | 24.2 | 1.5 | 4.0 | <T | 0.8 | <T | 0.002 | <W | 0.002 | <T | 0.180 | | 0.0005 | <W | 0.006 | <T | 0.18 | |
| 324 | 980722 | 24.4 | 9.0 | 4.0 | <T | 0.8 | <T | 0.010 | | 0.003 | <T | 0.205 | | 0.0005 | <W | 0.006 | <T | 0.20 | |
| 324 | 980722 | 24.4 | 23.0 | 10.0 | | 0.8 | <T | 0.006 | <T | 0.009 | | 0.295 | | 0.0005 | <W | 0.006 | <T | 0.18 | |